Evolution of the Luminosity-Metallicity-Stellar Mass correlation in a hierarchical scenario

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Summary. We study the evolution of the Stellar Mass-Metallicity Relation and the Luminosity-Metallicity Relation by performing numerical simulations in a cosmological framework. We find that the slope and the zero point of the Luminosity-Metallicity Relation evolve in such a way that, at a given metallicity, systems were ~ 3 mag brighter at $z = 3$ compared to galaxies in the local universe, which is consistent with the observational trend. The local Stellar Mass-Metallicity Relation shows also a good agreement with recent observations. We identify a characteristic stellar mass $M_c \sim 10^{10.2} M_\odot h^{-1}$ at which the slope of the MMR decreases for larger stellar masses. Our results indicate that M_c arises naturally as a consequence of the hierarchical building up of the structure .

1 Results and discussion

The Luminosity-Metallicity Relation (LMR) has been widely studied during the last two decades. In the local universe there is a clear correlation between the luminosity and the chemical abundance of galaxies in such a way that brighter systems tend to be more metal rich (e.g. [3]). Futhermore, recent observations have suggested that this correlation evolves with redshift (e.g. [2]). At a given luminosity systems seem to be less enriched in the past. Because of the difficulties in obtaining stellar mass, most studies have used galaxy luminosity as a surrogate. Recently, though, the relation between oxygen chemical abundance and stellar mass (MMR) has been estimated for local galaxies finding a well defined correlation [6]. In this work we study the MMR and the LMR by using chemo-dynamical simulations in a cosmological scenario, which allow us to follow the non-lineal growth of structure together with the chemical enrichment of the interestellar medium.

We have performed chemo-dynamical simulations by employing the chemical GADGET-2 [4]. A ΛCDM universe ($\Omega = 0.3, \Lambda = 0.7, \Omega_b = 0.04$ and $H_0 = 100h^{-1}$ km s^{-1}Mpc^{-1}, $h = 0.7$) was assumed. The simulated volume corresponds to a periodic cubic box of a comoving 10 Mpc h^{-1} side length. We have considered two runs initially resolved with 2×160^3 and 2×80^3 particles (for details see De Rossi et al. 2006 in preparation).

Our simulations predict a local LMR which is in good agreement with the observational findings (e.g. [2] among others). The slope and the zero

point of the LMR evolve with time in such a way that systems, at a given chemical abundance, are ~ 3 mag brighter at $z = 3$ compared with local ones. The major variations in chemical abundance are driven by the faintest systems. We have also analysed the MMR obtaining similar trends to those encountered by [6] for SDSS galaxies but with a displacement of ~ -0.25 dex in the zero point. This discrepancy may be due to the fact that the SDSS explores only the central regions of galaxies leading to an overestimation of the metal content of the systems. We also observe an excess of metals at lower masses for the simulated MMR which may be probably associated to the lack of strong energy feedback in our numerical model.

The metallicity of galactic systems tends to increase with stellar mass in a non-linear way. We have determined a characteristic mass $M_{\rm c} \sim 10^{10.2} M_{\odot} h^{-1}$ where the slope of the MMR decreases and the relation starts to flatten for larger masses [5]. It is important to note that this mass is independent of redshift and has been previously mentioned in the literature as a characteristic mass for galaxy evolution [1]. By examining the history of evolution of each individual galactic system, we found that those with stellar masses $M_* > M_{\rm c}$ have experienced important merger events at high redshift causing an acceleration in the transformation of gas into stars. At lower redshifts these systems are saturated of stars and hence, while their stellar mass significantly increases during a merger event, their metallicity remains almost the same. On the other hand less massive systems form their stars in a more passive way or by rich gas mergers leading to a more tight correlation between stellar mass and metallicity. Thus, the patterns of the MMR are closely related to the hierarchical aggregation of structure in a LCDM universe and hence it might be considered a fossil of this process.

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